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XXIX. *Observations upon the Art of making Steel.* By the Reverend DANIEL LITTLE, F. A. A.

AS steel is an article of commerce, and of great use both in the arts, manufactures and husbandry of every nation ; and as we have the best of iron already manufactured in *America*, it is thought that the manufacturing of steel of a good quality, deserves the attention and encouragement of those who wish the welfare of the United States. What time I could redeem from other necessary business for several years past, has been employed in such disquisitions and experiments, as might tend to facilitate the art of making steel, and others near akin to it.

Those writers upon the subject which I have met with tell us, that the principal difference between iron and steel consists in this, That the latter is combined with a greater quantity of phlogiston than the former. Phlogiston exists in all inflammable substances, and in some that are not inflammable. Charcoal, and the coals of bones, horns and hoofs of animals, have been used as fit substances for communicating phlogiston to iron in making steel.

Steel is sometimes made by fusion of ore or pig-iron. The method is similar to that of reducing pig-iron to malleable iron, with this difference, that as steel requires more phlogiston than is necessary to iron, all the means must be made use of that are capable of introducing into the iron a great deal of phlogiston ; that is, by keeping it, while in fusion, encompassed with an abundance of charcoal, &c.

The other method of making steel is by cementation, as it is called ; that is, to convert bar-iron into steel ; which is done by a cement made of those substances which contain the greatest quantity of phlogiston. Put the bar-iron with this cement in-

to a vessel that will bear a strong fire ; lute on a close cover, so as to prevent the cement taking flame and consuming ; put the vessel in a furnace where the bars may be kept red-hot till they are converted into steel, which will be in a longer or shorter time, according to the bigness of the bars, and the quantity of cement.

This latter method has chiefly engaged my attention, which method is pretty well known in some parts of *America*, and, for many years past, steel has been made by it in several of the United States. Yet, so far as I have been informed, it has generally been of an inferior quality, and very little used for edge tools, which I supposed could not arise from the quality of the iron, for we have the greatest variety, and the best sort, in many parts of the country. I then conjectured there might be found some other inflammable substance for a cement, which, if properly applied, would impregnate the iron with phlogiston more advantageously. And, after many experiments, I found a particular marine plant that requires no other preparation but drying and pulverizing, and is commonly known by the name of rock-weed, or rock-ware, and is in the greatest plenty on our rocky shores, coves, creeks and harbours of the sea. In making some experiments upon this plant for a flux powder, a small bit of iron was put into a crucible, and filled with the said cement ; and, very unexpectedly, after it had been in a little more than a cherry heat for five or six hours, it was converted into steel, which gave me the first hint of its use in making steel ; since which I have had repeated experience of its excellency for the same purpose.

It needs no other preparation than to be cut off from the rocks with a scythe or sickle, spread on the dry land 'till the rains have washed

washed off the greater part of the sea-salt, then dried and pulverized, then used as other cements are in making steel : or, instead of washing off the sea-salt, it is better for some particular kinds of iron, to neutralize it by adding a fixed alkali.

To two parts of the plant well dried and pulverized, add one part of good wood-ashes ; mix together and moisten the whole with water or rather urine to the consistence of a very thick paste.

It is well known that in every new art, and in perfecting old ones, many unforeseen difficulties arise, and sometimes considerable fortunes have been spent before the manufacturer or the public have been much benefited. And since honest, but too credulous minds are often deceived by uncertain proof, and being willing to satisfy myself and others, by a better testimony than my own, I engaged a * gentleman of ability in the steel way for many years, whose furnace was complete and large, to make experiments upon my new discovered substance for a cement, who has written me, that “ this steel is preferable to any he had ever made before.” After all, I suppose different modes of preparation and further experiments will more fully ascertain its utility.

The matter of the furnace must be of such substances as will endure a strong fire without fusion. Asbestos has been used to advantage, but a sufficiency of it is not found in many places. Pipe-clay with one third part of pond-sand, or, which is better, white stones free from grit, well burnt, and pulverized, instead of sand, some species of slate and tale may be used with pipe-clay for furnaces and crucibles.

The chest or interior part of the furnace, for depositing the cement and bars of iron, must be covered so close that the inflammable substance within may not be consumed, but changed

* Col, Elliot of Connecticut,

like wood in a coal-kiln. The iron to be chosen of the best quality ; its toughness and malleability are marks of choice.

Of the ore of iron.—This is often discovered by the magnet, but a great part of the best ore is that which the magnet will not attract, as *Linnaeus* and *Macquer* justly observe. When in that state it often resembles the rust or calx of iron. Many tuns of which are brought to the iron-works in this neighbourhood, from which the best of iron is made. In its natural state the best magnetic bar will not attract the smallest particle ; but when roasted with charcoal it becomes magnetic. This method of knowing whether any earth or stones contain the true ore of iron, may be of use to discover new bodies or beds of ore. The reduction of metals, or restoring them to their metallic state from their calces, by combining them with the inflammable principle in the application of charcoal, may sufficiently show the efficacy of the above method for the discovery of the earth of iron in those substances on which the magnet has no effect.

